Investigating The Impact Of Textural Heterogeneity On Quantifying Clay Minerals In Sandstones: A Controlled Laboratory Experiment

A.M. Alqubalee, King Fahd University of Petroleum & Minerals; M. Al-Hashem, KFUPM; B.D. Al-Otaibi, A.O. Amao, L. Babalola, K. Al-Ramadan, King Fahd University of Petroleum & Minerals; C. Afagwu, KFUPM

Abstract

Objectives/Scope: Sandstones contain clay minerals that can fill pore spaces, coat grains, or bridge pore throats, and may impact the quality of reservoirs, aquifers, and CO2 storage capacity. Quantifying clay mineral proportions is critical for understanding their effects on reservoir quality. However, it can be challenging due to laboratory technique limitations. This study utilizes Empyrean X-ray powder diffraction (XRD) and Quantitative Evaluation of Minerals by Scanning Electron Microscopy 650F (QEMSCAN) to quantify kaolinite (K) mixed with aeolian quartz (Q) in a controlled experiment.

Methods, Procedures, Process: Twenty-two (22) samples comprising both homogeneous (H) and heterogeneous (Ht) samples, were analyzed. The H samples were in powder form with varying K% proportions (0, 1, 5, 9, 17, 23, 29, 33, 38, 41, 44, and 100%). On the other hand, the Ht samples were unpowdered Q grains of different grain sizes, including very fine (vF), fine (F), medium (M), coarse (C), and very coarse (vC), each with a fixed 5% K content. Although QEMSCAN can analyze both H and Ht samples, the XRD technique is limited to analyzing the H samples.

Results, Observations, Conclusions: The H sample results indicate a strong correlation (R2 = 0.97) between the actual K% and the K% measured by both XRD and QEMSCAN; however, they tend to underestimate the actual K% values. The underestimated difference (Ud) ratios, which represent the percentage difference between measured and actual K% values, vary for both techniques. For samples with K% values between 5 and 100, the coefficient of variation (CV) for Ud is 17% in XRD (range = 19-35%, average = 28%), while it is 88% in QEMSCAN (range = 9-84%, average = 33%). The Ud is highest for both techniques at 1% (Ud > 85%) K and lowest at 100% K. The Ud in Ht samples is lowest with vF and F, and highest with M, C, and vC. It was observed that increasing Q% impacts the measured K in XRD, while QEMSCAN is impacted by larger grain sizes.

Novel/Additive Information: Understanding these technical limitations can help to evaluate textural heterogeneity, reduce uncertainty in quantifying clay minerals, and better understand their impact on sandstone petrophysical properties.